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(54) Panoramic imaging system

(57) Vertical and horizontal swivels 4, 6 enable a camera 2 of relatively narrow field of view, e.g. 3° x 2°, to cover a wide field, e.g. 60° x 3°; successive narrow views 26i...26x are transmitted to a memory at positions corresponding to the camera direction and reproduced therefrom in corresponding positions on a display screen, for example as four stacked strips of joined narrow views, each strip 3° high and 15° wide (Figure 1B). A second screen may show a close-up of one narrow view. If the camera is in a moving aircraft or ground vehicle, absolute displacement of views may be prevented by control of the swivels in response to signals from fixed-spaced orientation detectors. Residual stabilisation errors may be detected by correlation of corresponding views of successive sweeps, and corrected electronically by image displacement. The swivels may displace the camera and/or a mirror in front of the camera. The memory may be a digital frame store or involve afterglow.

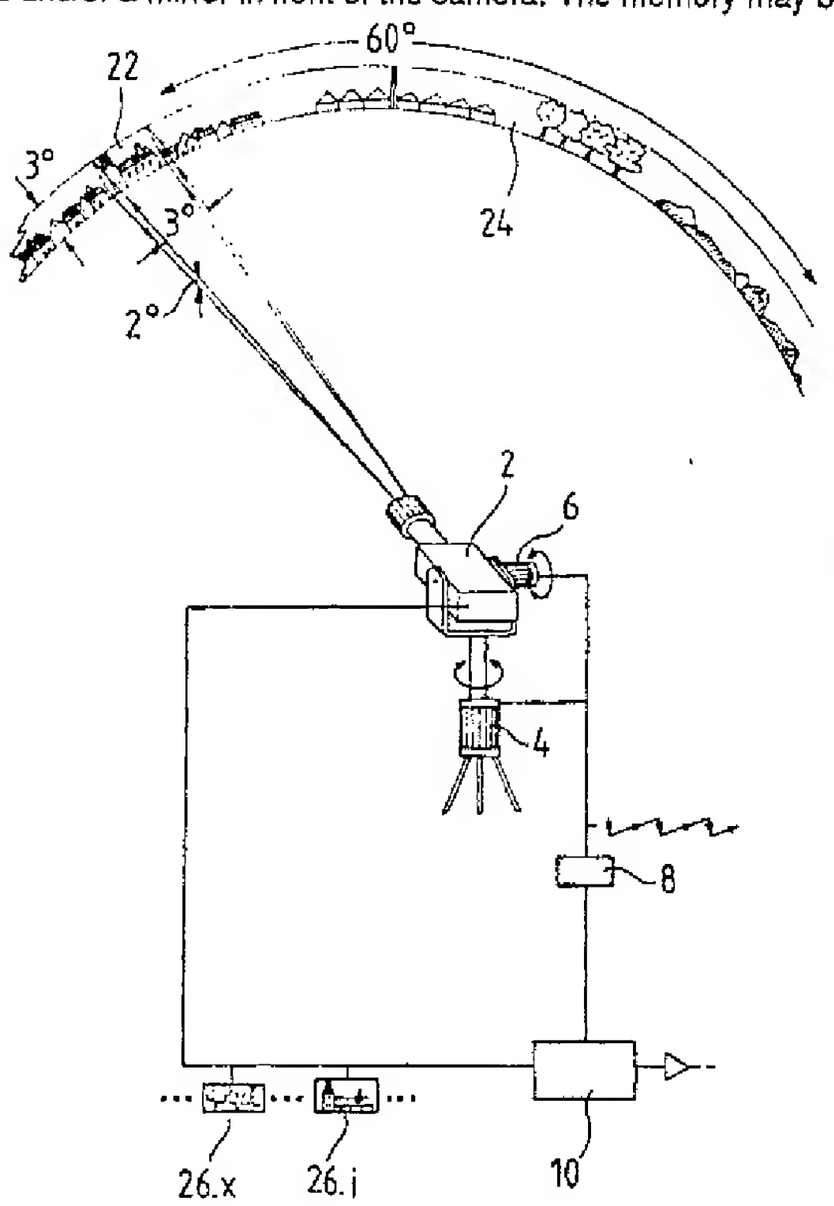

FIG. 1A

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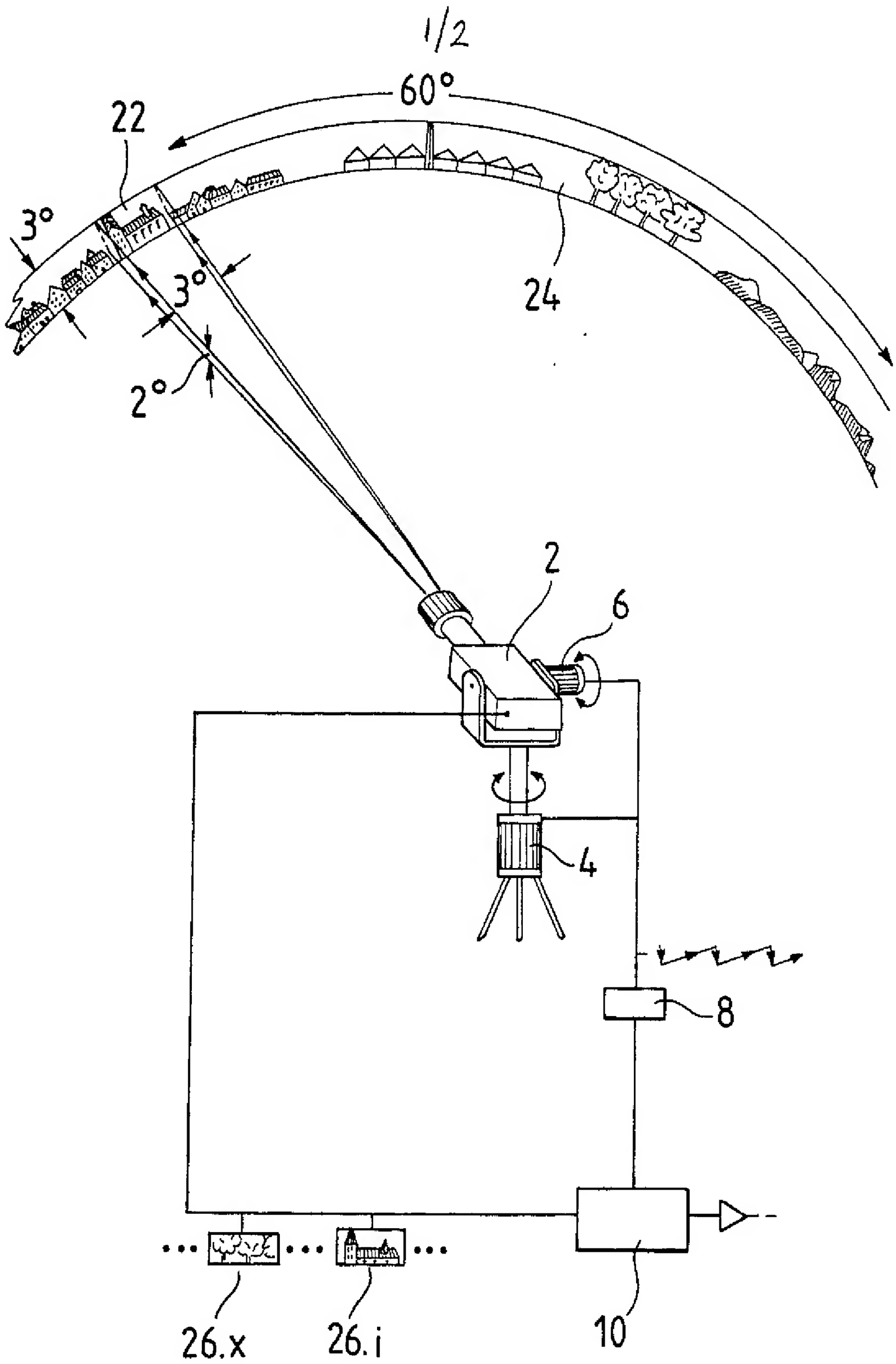

FIG. 1A

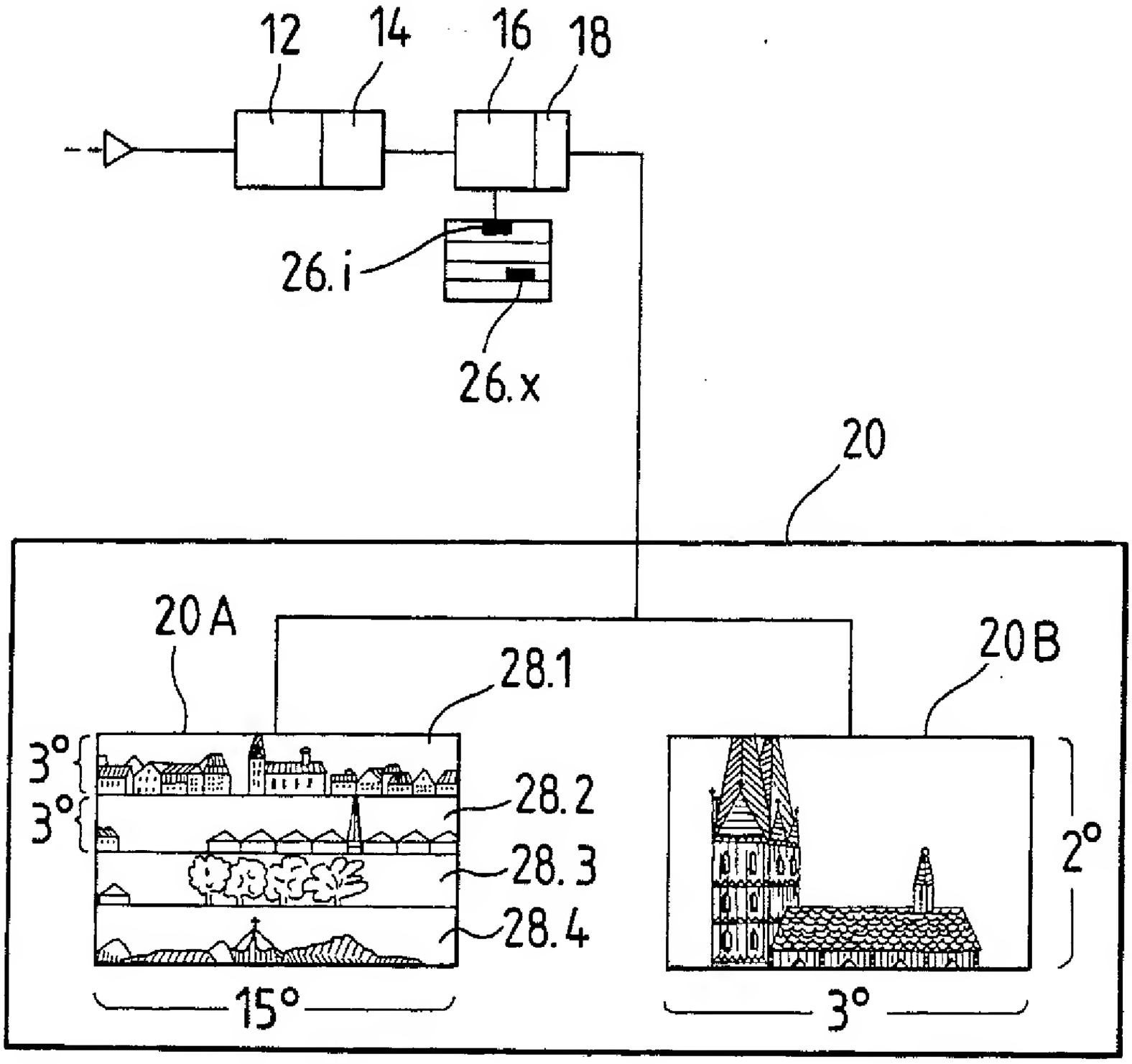

FIG. 1B

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IMAGING SYSTEM

This invention relates to an imaging system (sometimes called a visionic system) comprising a camera to cover the scene to be observed, image-transfer means connected thereto at the output side, and a display unit, optically displaying the scene in stacked image strips. Such apparatus is used, for example, for large area observation of an overall scene, for example that of a landscape, as well as for identification of individual, remote and normally moving objects of the scene, from aircraft, vehicles or ships, but also from fixed observation stations.

German patent specification 26 20 699 discloses an imaging system for aircraft, whereby the scene ahead of the aircraft is simultaneously covered by several cameras, which are firmly attached to the aircraft and operate parallel to one another, in horizontally adjacent partial scenes with viewing angles each of approximately 2° in the vertical direction, and approximately 10° in the horizontal direction, and imaged on a screen in stacked image strips. In addition thereto, a limited section of an overall scene is shown in enlarged form for recognition and identification of remote objects in the scene, by way of a further camera,

which is firmly attached to the aircraft, covers a considerably smaller image field and is aligned co-axially to the aircraft axis. This known imaging system requires a great deal of technical equipment and is restricted with respect to high identification range of objects in the centre of the observation field.

The object of the invention is to improve the aforedescribed imagining system in a constructionally simple manner so that it can be used to obtain both a clear overall image presentation of an observation scene which covers a large vision angle, and a high geometric resolution and range of recognition and identification of remote objects at any location in the overall scene.

This object is achieved according to the invention in that the camera image field, limited to a defined section of the scene, is displayed on the display unit as an image section of changeable position, in that means swivelling the image field of the camera across the scene is associated with the camera, and in that the image-transfer means is provided with an image-control unit which changes the position on the display unit in conformity with the movement of the swivelling means.

The inventive imaging system produces, by way of a single camera with a single image field, which is chosen

to be small by comparison with the entire observation field, and in conjunction with special movement control and image processing, an overall image of the observation field, divided into individual image strips, and simultaneously therewith for each scene section a geometric high resolution relative to the narrow image field of the camera, which makes it possible at all times to effortlessly aim at and identify any remote object in the overall scene by electronic means alone and without expensive mechanical image-field switchover.

The inventive imaging system is thus eminently suitable for applications which require, in a constructionally easy way, the imaging of large area observation fields both in a clear overall image and in a precisely detailed, selectable image section. In an advantageous development of the invention, the display unit is associated with an image store, preferably in the form of an afterglow screen in the form of a digital frame store, whereby the image information of an image section remains intact until the next swivel cycle, even with relatively low-frequency swivelling movement of the swivelling device.

The size of the sectional image on the monitor relative to the image field of the camera is preferably adjustable, advantageously by means of a digital image-

processing stage. This allows production, in constructionally simple, user-friendly manner, of a wide range precision-detailed image of a scene section which is freely selectable relative to its positioning and size.

In advantageous embodiments of the invention both the overall image of the scene and the overall-image section, selected relative to the required identification range, are simultaneously shown on the monitor, thus making observation and object identification easier, in which respect either two adjacent screen fields are provided on the monitor, or, preferably, two separate screens.

Both the size and the spatial orientation of the observation field are advantageously adjustable by swivelling movement around two axes, so that the angle size and position of the observation field can be variably selected, and, independent thereof, the image angle of the camera alone can be set relative to the maximum identification range.

The swivelling means are preferably provided with a directional drive, which swivels the camera around at least one axis, or a directional-mirror system arranged in front of the camera. In practice, these are

advantageously combined so that the directional drive is provided for scanning and setting of the observation field relative to size and position and for rough stabilization in the horizontal direction, whilst the directional-mirror system attends to the horizontal fine stabilization, and in the vertical direction to the scanning and setting of the observation field as well as fine- and rough stabilization.

If the imaging system is mounted on a moving support structure, for example an aircraft or ground vehicle, then image displacement due to movements of the support structure can be prevented with the aid of fixed-space oriented position transmitters so that the scanning movement of the swivelling means and the image control on the monitor are related to a fixed-space co-ordinates system.

In preferred embodiments an electronic image-correlation stage, which is associated with the image-control unit, is provided in addition to or as a replacement of the mentioned fine stabilization for increasing the quality of stabilization. In this respect, any remaining stabilising fault, originated on the side of the camera, is detected by way of electronic comparison of two images of the same scene section of two successive swivel cycles of the swivelling means and corrected in a

purely electronic way down to pixel size by horizontal or vertical image displacement.

It is advisable to set the size of the image field of the camera so small that it is in practical application maximum 1/10 of the overall size of the observation field.

An exemplary practical embodiment of the imaging system according to the invention will now be described in more detail with reference to the accompanying drawings, Figs. 1A and 1B of which illustrate same in diagrammatic manner.

The illustrated imaging system comprises as main components a camera 2 in the form of a thermal image- or low-light level- or conventional TV camera with, for example 625 image lines and 600 picture elements per line, which are scanned with an image frequency of 25 Hz in continuous scan, ie. without interlacing, swivelling means 4, 6, 8 associated with camera 2, as well as image-transfer means 10, 12, comprising transmitter- and receiver sections including an image-control unit 14 (Fig. 1B), a digital frame store 16, which is associated with a digital image-processing stage 18, and a display unit 20 with screens 20A and 20B.

As indicated in Fig. 1A, camera 2 has an image field 22, selected to be only small, of constant size of, for example 2° in the vertical, and 3° in the horizontal direction, resulting in high geometric resolution and large identification range, whilst the overall scene to be observed extends over a substantially larger field of vision 24 of, for example 3° x 60°.

By means of swivelling means 4, 6, 8 the camera 2 is swivelled back and forth in the horizontal and vertical direction in such a manner that the camera image field 22 passes over the entire observation field 24 once in every swivelling cycle. For this purpose, the swivelling means incorporates control motors 4, 6 in co-ordination with the size and position of the desired observation field 24, for example as indicated by the saw-tooth shaped movement path in Fig. 1A.

The swivelling means also includes a directional mirror (not shown), arranged in front of camera 2 and driven by control motors 4, 6 in two axes, and a directional drive active in the horizontal direction, for both the camera 2 and the directional mirror. The directional drive attends to scanning the observation field 24 in the horizontal direction, rough stabilization and directional movement, and the directional mirror is

provided in the vertical direction for scanning the observation field 24, fine- and rough stabilization and directional movement, and in the horizontal direction for fine stabilization.

The displacement of images, caused by movement of the support structure itself, ie. while the imaging system is attached to a moving aircraft or ground vehicle, and due to overlaid camera movement, is prevented by way of spatially fixed orientated position transmitters (not illustrated), which effect the swivelling means via signal transmitter 8 in such a way that scanning the observation field 24 is independent of the movements of the support structure itself in a spatially fixed reference system. It is thus guaranteed that maximum resolution in the small image field 22 is achieved at any state of movement of camera 2. Maximum scanning speeds are only dependent on the output of control motors 4, 6 and the digital frame store 16.

Sectional images 26.i... 26.x..., resulting from the scanning movement and changing in sequence with time, are converted into a relative image signal due to the continuous swivelling movement of camera 2, relative to a spatially fixed co-ordinates system, and are passed together with the swivelling signals of the swivelling means 4, 6, 8 to the image-transfer means 10, 12. The

latter is associated with an image-control unit 14, which synchronises the images of the camera 2 in such a manner that the individual sectional images 26.i... 26.x... are stored one after the other in different memory locations in the digital frame store 16, ie. in alignment with their position in the spatially fixed observation field 24. Consequently, the entire scene is stored in memory 16 as a static image with an image frequency (for example 1 Hz) equalling that of the swivelling frequency of the swivelling means 4, 6, 88 and with a very high geometric resolution, in which respect the storage capacity is greater by multiples relative to the ratio of maximum observation-field size and image-field size than the number of picture elements of cameras 2. The image store 16 is associated with an image-processing stage 18, through which any desired full-image section, down to the smallest field of vision, preset by image field 22 of camera 2, of maximum identification range with increasing precision in detail, can be recalled for display on monitor 20.

Generally, the scene comprises a long stretched observation field 24 with a large horizontal, but comparatively small vertical vision angle. For making full use of the monitor surface and achieving maximum precision of detail during the display, the overall image of observation field 24 is arranged on monitor 20

into different stacked image strips 28.1 to 28.4 as is shown on screen 20A in Fig. 1B. Scene sections with a horizontal vision angle which is large relative to the vertical angle, are also shown in stacked image strips 28. A single image section 26 is shown over the entire screen surface for maximum identification range, as is shown in Fig. 1B for image section 26.i on screen 20B. It is also possible to display a section thereof over the full screen 20B with the same precision in detail as in the display of image field 22.

By changing the directional angle, which defines the swivelling range of the swivelling means any observation field can be covered and displayed. If the scanning movement of swivelling means is switched off whilst maintaining the stabilising effect of the spatially fixed oriented position transmitter, then the image display of the respective image section 26 is at an image frequency of 25 Hz.

To increase the stabilization quality or to relieve or completely replace the described image stabilization, the image-control unit 14 can be associated with an image-correllation stage, with the aid of the which a camera fault in the remaining stabilization fault can be detected by electronic comparison of two sectional images 26 of the same scene section of two successive

scanning cycles, and can then be corrected by purely electronic means down to pixel size by horizontal and vertical image displacement.

C L A I M S

1. An imaging system, comprising a camera to cover the scene to be observed, image-transfer means connected thereto at the output side, and a display unit, optically displaying the scene in stacked image strips, characterised in that the camera image field, limited to a defined section of the scene, is displayed on the display unit as an image section of changeable position, in that means swivelling the image field of the camera across the scene is associated with the camera, and in that the image-transfer means is provided with an image-control unit which changes the position on the display unit in conformity with the movement of the swivelling means.

2. An imaging system as claimed in claim 1, wherein the display unit is associated with an image store.

3. An imaging system as claimed in claim 2, wherein the display unit is provided with an afterglow picture screen, which is an image store.

4. An imaging system as claimed in claim 2, wherein the display unit is associated with a digital frame store.

5. An imaging system as claimed in any preceding claim wherein the size of the image section relative to the image field of the camera is adjustable on the display unit.

6. An imaging system as claimed in claim 5, wherein the image transfer means comprises a digital image-processing stage for selective change in size of the image section on the display unit.

7. An imaging system as claimed in any preceding claim wherein scene sections, covered by the image field of the camera, are simultaneously displayed on the display unit on the one hand as image sections, which move relative to the swivelling movement of the swivelling means and combine to an overall scene, and on the other hand in a separate section of the display unit, each enlarged and as selectable overall-image sections.

8. An imaging system as claimed in claim 7, wherein the display unit has separate picture screens, on the one hand for the overall image, and on the other hand for the overall-image section.

9. An imaging system as claimed in any preceding claim wherein the swivelling range of the swivelling means is adjustable both in its size and its spatial orientation.

10. An imaging system as claimed in any preceding claim wherein the swivelling means is driven to be swivelled both in the horizontal and vertical direction.

11. An imaging system as claimed in any preceding claim wherein the swivelling means comprises a directional drive swivelling the camera around at least one axis.

12. An imaging system as claimed in any preceding claim wherein the swivelling means comprises a directional-mirror system, arranged in front of the camera and including a swivelling drive, which system scans the scene and deflects its image into the camera.

13. An imaging system as claimed in any preceding claim wherein the swivelling means comprises spatially fixed orientated position indicators for movement control thereof relative to a spatially fixed co-ordinates system.

14. An imaging system as claimed in any preceding claim wherein the image-control unit comprises an electronic image-correlation stage for image stabilization.

15. An imaging system as claimed in any preceding claim wherein the observation field is at least 10 times the size of the image field of the camera.

16 An imaging system substantially as hereinbefore described with reference to and as illustrated by the accompanying drawings.

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